U. S. DEPARTMENT OF AGRICULTURE.

THE RELATION OF FORESTS TO FARMS.

By B. E. FERNOW,
Chief of the Division of Forestry.

TREE PLANTING IN THE WESTERN PLAINS.

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THE RELATION OF FORESTS TO FARMS.

By B. E. Fernow,

Chief of the Division of Forestry, U. S. Department of Agriculture.

That all things in nature are related to each other and interdependent is a common saying, a fact doubted by nobody, yet often forgotten or neglected in practical life. The reason is partly indifference and partly ignorance as to the actual nature of the relationship; hence we suffer, deservedly or not.

The farmer's business, more than any other, perhaps, depends for its success upon a true estimate of and careful regard for this interrelation. He adapts his crop to the nature of the soil, the manner of its cultivation to the changes of the seasons, and altogether he shapes conditions and places them in their proper relations to each other and adapts himself to them.

Soil, moisture, and heat are the three factors which, if properly related and utilized, combine to produce his crops. In some directions he can control these factors more or less readily; in others they are withdrawn from his immediate influence, and he is seemingly helpless. He can maintain the fertility of the soil by manuring, by proper rotation of crops, and by deep culture; he can remove surplus moisture by ditching and draining; he can, by irrigation systems, bring water to his crops, and by timely cultivation prevent excessive evaporation, thereby rendering more water available to the crop; but he can not control the rainfall nor the temperature changes of the seasons. Recent attempts to control the rainfall by direct means exhibit one of the greatest follies and misconceptions of natural forces we have witnessed during this age. Nevertheless, by indirect means the farmer has it in his power to exercise much greater control over these forces than he has attempted hitherto. He can prevent or reduce the unfavorable effects of temperature changes; he can increase the available water supplies, and prevent the evil effects of excessive rainfall; he can so manage the waters which fall as to get the most benefit from them and avoid the harm which they are able to inflict.

The following three illustrations, shown as models at the Atlanta Exposition, are designed to bring graphically before the reader the evil effects of the erosive action of water, the methods by which the farmer may recuperate the lost ground, and the way the farm should look when forest, pasture, and field are properly located and treated.

FIG 80.—How the farm is destroyed.

Clearing of hilltops, excessive thinning of wooded hillsides, followed by the burning of litter, underbrush, and young growth, and the compacting of the soil by the tramping of animals, induces rapid surface drainage, and this causes erosion, gullying. and washing away of the soil.

The surface water rushing unimpeded over bare slopes and compacted soils washes away the soil, cuts gullies in fields on hillsides, and washes down silt, sand, and gravel, and spreads them over fields and meadows; thus the fertile portions of the farm are injured by the encroachment from the unfertile.

FIG. 81.—How the farm is regained.

To prevent erosion, gullying, and washing, keep hilltops and steep hillsides under forest; change surface drainage into under-ground drainage; check the rush of water by means of brush and stone dams, terracing, contour plowing, and ditching; renew organic matter in the soil by means of green manuring and mulching, and give thorough cultivation.

The rush of water must be checked by means of dense forest growth on the tops and steepest sides of hills—places where floods acquire their momentum. At such points gullies should be filled with brush and stone work, runs filled up with brush, and the soil so treated that it will permit the water to pass through it and flow off under ground.

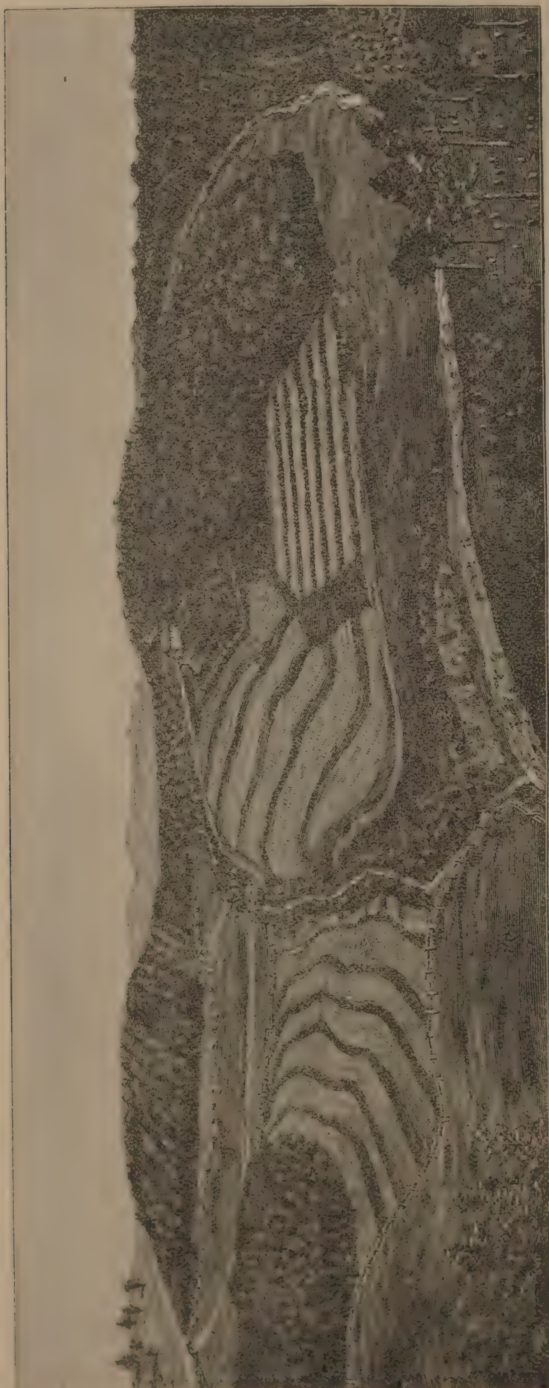

FIG. 82.—How the farm is retained.

On the ideal farm there is no waste land, every foot of ground being used for the purpose for which it is best adapted. The farm is divided into cultivated fields, pasture, and woodland, a proper proportion of ground being devoted to each; roads are made with a view to convenience and grade, and stock is fenced into the pasture—not out of the fields. Damage caused by water is to be repaired at once. Hilltops, steep hillsides, and rocky places are kept under forest. A fringe of wood stretches along river banks, and long slopes are broken up with small groves or timber belts. Wood is cut systematically and judiciously, so that it will reproduce. Where natural reproduction fails, replanting is resorted to. The pasture is located on a gentle slope where the soil is too thin for field crops.

The regulation, proper distribution, and utilization of the rain waters in arid as well as in humid regions—water management—is to be the great problem of successful agriculture in the future.

One of the most powerful means for such water management lies in the proper distribution and maintenance of forest areas. Nay, we can say that the most successful water management is not possible without forest management.

THE FOREST WATERS THE FARM.

Whether forests increase the amount of precipitation within or near their limits is still an open question, although there are indications that under certain conditions large, dense forest areas may have such an effect. At any rate, the water transpired by the foliage is certain, in some degree, to increase the relative humidity near the forest, and thereby increase directly or indirectly the water supplies in its neighborhood. This much we can assert, also, that while extended plains and fields, heated by the sun, and hence giving rise to warm currents of air, have the tendency to prevent condensation of the passing moisture-bearing currents, forest areas, with their cooler, moister air strata, do not have such a tendency, and local showers may therefore become more frequent in their neighborhood. But, though no increase in the amount of rainfall may be secured by forest areas, the availability of whatever falls is increased for the locality by a well-kept and properly located forest growth. The foliage, twigs, and branches break the fall of the raindrops, and so does the litter of the forest floor, hence the soil under this cover is not compacted as in the open field, but kept loose and granular, so that the water can readily penetrate and percolate; the water thus reaches the ground more slowly, dripping gradually from the leaves, branches, and trunks, and allowing more time for it to sink into the soil. This percolation is also made easier by the channels along the many roots. Similarly, on account of the open structure of the soil and the slower melting of the snow under a forest cover in spring, where it lies a fortnight to a month longer than in exposed positions and melts with less waste from evaporation, the snow waters more fully penetrate the ground. Again, more snow is caught and preserved under the forest cover than on the wind-swept fields and prairies.

All these conditions operate together with the result that larger amounts of the water sink into the forest soil and to greater depths than in open fields. This moisture is conserved because of the reduced evaporation in the cool and still forest air, being protected from the two great moisture-dissipating agents, sun and wind. By these conditions alone the water supplies available in the soil are increased from 50 to 60 per cent over those available on the open field. Owing to these two causes, then—increased percolation and decreased evaporation—larger amounts of moisture become available to feed the springs

and subsoil waters, and these become finally available to the farm, if the forest is located at a higher elevation than the field. The great importance of the subsoil water especially, and the influence of forest areas upon it, has so far received too little attention and appreciation. It is the subsoil water that is capable of supplying the needed moisture in times of drought.

THE FOREST TEMPERS THE FARM.

Another method by which a forest belt becomes a conservator of moisture lies in its wind-breaking capacity, by which both velocity and temperature of winds are modified and evaporation from the fields to the leeward is reduced.

On the prairie, wind swept every day and every hour, the farmer has learned to plant a wind-break around his buildings and orchards, often only a single row of trees, and finds even that a desirable shelter, tempering both the hot winds of summer and the cold blasts of winter. The fields he usually leaves unprotected; yet a wind-break around his crops to the windward would bring him increased yield, and a timber belt would act still more effectively. Says a farmer from Illinois:

> My experience is that now in cold and stormy winters fields protected by timber belts yield full crops, while fields not protected yield only one-third of a crop. Twenty-five or thirty years ago we never had any wheat killed by winter frost, and every year we had a full crop of peaches, which is now very rare. At that time we had plenty of timber around our fields and orchards, now cleared away.

Not only is the temperature of the winds modified by passing over and through the shaded and cooler spaces of protecting timber belts disposed toward the windward and alternating with the fields, but their velocity is broken and moderated, and since with reduced velocity the evaporative power of the winds is very greatly reduced, so more water is left available for crops. Every foot in height of a forest growth will protect 1 rod in distance, and several belts in succession would probably greatly increase the effective distance. By preventing deep freezing of the soil the winter cold is not so much prolonged, and the frequent fogs and mists that hover near forest areas prevent many frosts. That stock will thrive better where it can find protection from the cold blasts of winter and from the heat of the sun in summer is a well-established fact.

THE FOREST PROTECTS THE FARM.

On the sandy plains, where the winds are apt to blow the sand, shifting it hither and thither, a forest belt to the windward is the only means to keep the farm protected.

In the mountain and hill country the farms are apt to suffer from heavy rains washing away the soil. Where the tops and slopes are bared of their forest cover, the litter of the forest floor burnt up, the soil trampled and compacted by cattle and by the patter of the

raindrops, the water can not penetrate the soil readily, but is carried off superficially, especially when the soil is of clay and naturally compact. As a result the waters, rushing over the surface down the hill, run together in rivulets and streams, and acquire such a force as to be able to move loose particles, and even stones; the ground becomes furrowed with gullies and runs; the fertile soil is washed away; the fields below are covered with silt; the roads are damaged; the water courses tear their banks, and later run dry because the waters that should feed them by subterranean channels have been carried away in the flood.

The forest cover on the hilltops and steep hillsides which are not fit for cultivation prevents this erosive action of the waters by the same influence by which it increases available water supplies. The important effects of a forest cover, then, are retention of larger quantities of water and carrying them off under ground and giving them up gradually, thus extending the time of their usefulness and preventing their destructive action.

In order to be thoroughly effective, the forest growth must be dense, and, especially, the forest floor must not be robbed of its accumulations of foliage, surface mulch and litter, or its underbrush by fire, nor must it be compacted by the trampling of cattle.

On the gentler slopes, which are devoted to cultivation, methods of underdraining, such as horizontal ditches partly filled with stones and covered with soil, terracing, and contour plowing, deep cultivation, sodding, and proper rotation of crops, must be employed to prevent damage from surface waters.

THE FOREST SUPPLIES THE FARM WITH USEFUL MATERIAL.

All the benefits derived from the favorable influence of forest belts upon water conditions can be had without losing any of the useful material that the forest produces. The forest grows to be cut and to be utilized; it is a crop to be harvested. It is a crop which, if properly managed, does not need to be replanted; it reproduces itself.

When once established, the ax, if properly guided by skillful hands, is the only tool necessary to cultivate it and to reproduce it. There is no necessity of planting unless the wood lot has been mismanaged.

The wood lot, then, if properly managed, is not only the guardian of the farm, but it is the savings bank from which fair interest can be annually drawn, utilizing for the purpose the poorest part of the farm. Nor does the wood lot require much attention; it is to the farm what the workbasket is to the good housewife—a means with which to improve the odds and ends of time, especially during the winter, when other farm business is at a standstill.

It may be added that the material which the farmer can secure from the wood lot, besides the other advantages recited above, is of far greater importance and value than is generally admitted.

On a well-regulated farm of 160 acres, with its 4 miles and more of fencing, and with its wood fires in range and stove, at least 25 cords of wood are required annually, besides material for repair of buildings, or altogether the annual product of probably 40 to 50 acres of well-stocked forest is needed. The product may represent, according to location, an actual stumpage value of from $1 to $3 per acre, a sure crop coming every year without regard to weather, without trouble and work, and raised on the poorest part of the farm. It is questionable whether such net results could be secured with the same steadiness from any other crop. Nor must it be overlooked that the work in harvesting this crop falls into a time when little else could be done.

Wire fences and coal fires are, no doubt, good substitutes, but they require ready cash, and often the distance of haulage makes them rather expensive. Presently, too, when the virgin woods have been still further culled of their valuable stores, the farmer who has preserved a sufficiently large and well-tended wood lot will be able to derive a comfortable money revenue from it by supplying the market with wood of various kinds and sizes. The German State forests, with their complicated administrations, which eat up 40 per cent of the gross income, yield, with prices of wood about the same as in our country, an annual net revenue of from $1 to $4 and more per acre. Why should not the farmer, who does not pay salaries to managers, overseers, and forest guards, make at least as much money out of this crop, when he is within reach of a market?

In regard to the manner in which the farmer should manage his wood lot, the Yearbook of 1894 gives a fuller account.

With varying conditions the methods would of course vary. In a general way, if he happens to have a virgin growth of mixed woods, the first care would be to improve the composition of the wood lot by cutting out the less desirable kinds, the weeds of tree growth, and the poorly grown trees which impede the development of more deserving neighbors.

The wood thus cut he will use as firewood or in any other way, and even if he could not use it at all, and had to burn it up, the operation would pay indirectly by leaving him a better crop. Then he may use the rest of the crop, gradually cutting the trees as needed, but he must take care that the openings are not made too large, so that they can readily fill out with young growth from the seed of the remaining trees, and he must also pay attention to the young aftergrowth, giving it light as needed. Thus without ever resorting to planting he may harvest the old timber and have a new crop taking its place and perpetuate the wood lot without in any way curtailing his use of the same.

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TREE PLANTING IN THE WESTERN PLAINS.

By Charles A. Keffer,
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CHARACTERISTIC FEATURES OF THE PLAINS.

The plains of the West comprise a strip of country of varying width extending from North Dakota to Texas, all portions of which have the same general characteristic features. In the eastern part of this region the country is like the adjacent prairies of Minnesota, Iowa, and Missouri—rolling lands, with numerous streams bordered by woods, from which the surface rises to the open country. In the Dakotas and northern Nebraska these slopes are usually gentle, but in Kansas the surface of the land is frequently broken by outcrops of the underlying limestone. Farther south the woods increase in extent. Through the central area of the Western States (the Dakotas, Nebraska, Kansas, Oklahoma, and Texas) the tree growth is greatly reduced in extent and variety, the country is less rolling, and the altitude is higher, these conditions increasing in intensity westward until in eastern Colorado there is a vast plain rising by imperceptible degrees toward the foothills of the Rocky Mountains.

Aside from these generally prevailing conditions, the State of Nebraska is crossed east and west by a broad belt of sand hills, which make it necessary to discuss that region separately from the remaining country under consideration. A somewhat similar area, though very much smaller in extent and less pronounced in character, lies between the Arkansas and Smoky Hill rivers in Kansas.

The soil conditions over this vast area are necessarily variable. The Dakotas and Nebraska outside of the sand hills have what Western people recognize as the typical prairie soil—a deep clay loam, underlaid with a subsoil of clay of varying degrees of stiffness. Oftentimes on adjoining farms this subsoil presents widely varying characteristics; the one being almost impenetrable to moisture (the hardpan of the Northwest), and the other having a considerable admixture of sand and readily penetrated by moisture.

The surface soil is usually black in color, and, except in cases of extreme drought, can be kept in good condition, so far as moisture is concerned, by very deep plowing and frequent shallow cultivation. In Kansas and the southern country the same loamy surface soil is found, but the subsoil is frequently of a more calcareous nature, being

underlaid with limestone not far from the surface. In Colorado the surface soil is brown rather than black, and has the characteristic clay subsoil of the more northern region.

The vegetation throughout consists of grasses, composites, and legumes, with a comparatively small number of other species, almost exclusively herbaceous, except in the immediate vicinity of streams. The only common woody plants on the uplands are low-growing roses, cherry, and false indigo. The soil cover is less luxuriant, generally speaking, from east to west and from the lower to the higher latitudes, being of course largely governed by the presence of moisture in soil and atmosphere. In the moister regions the taller forms of Andropogon and Calamagrostis are the characteristic grasses, while in the drier regions the Stipas, Boutelouas, and Buchloes are dominant. The annual prairie fires have prevented as large accumulations of humus as the grass crop would otherwise have made, but the soil is nowhere lacking in an abundant supply of food elements for trees.

In all the Northern prairies there is an almost insensible passage from surface to subsoil, the change in color and grain being a very gradual one, evidently dependent on the amount of humus. It not infrequently happens that a thin stratum of coarse gravel or gravelly clay makes a line of demarcation between surface and subsoil. Throughout the plains, too, it is common to find white spots, calcareous in nature, in the clay subsoil from 3 to 10 feet below the surface. By many persons in the West these chalky deposits are wrongly considered an indication of hardpan, impenetrable to moisture. There is also a greater or less admixture of fine sand in the clay subsoil; in most cases this sand is sufficient to render the subsoil porous enough to permit the free passage of moisture. This is proven by the almost universal effect of shallow culture on deep-plowed prairie soils. The land so tilled is fresh below the dust blanket even in long periods of drought, while adjacent uncultivated land shows wide cracks on the surface of the baked earth. There are undoubtedly places, local in character and of limited extent, in which the subsoil is too stiff to permit a good growth of forest trees, but these can be regarded as exceptions rather than the rule, which is that the soils of the plains are of sufficient depth and porosity to permit the growth of trees. Whatever difficulties are met, then, must be climatic in their nature.

The mean annual rainfall gradually decreases from the eastern boundaries of Kansas and Dakota toward the mountains. The greatest rainfall occurs in the southeastern part of the region, and a gradual decrease is noticeable both northward and westward, being greater in the latter direction. On the unbroken prairies the character of the soil and vegetation has much to do with the moisture conditions. There is usually a good fall of rain during April, May, and June; then there is apt to be very little until the autumn months. During this

long interval the only protection to the soil is the herbaceous vegetation that covers it, and this is soon turned brown and sere by the excessive heat and winds. The sun, beating down on the scarcely shaded earth, tends to compact and bake it until it more nearly resembles sun-dried brick than a soil in which plants can grow. This condition varies in proportion to the amount of sand in the soil, and as the greater part of the plains is covered with a clay loam, they dry out badly and have become very compact during the centuries that they have been exposed to existing conditions. When rains fall, the water is not absorbed by such soils to as great a degree as in the prairie loams of Iowa and Missouri. It penetrates a few inches, only to be soon evaporated. Under cultivation, however, a decided change in the action of Western soils is noticeable. This was impressed upon the writer during a visit to the Kansas State forest station at Ogallah (99° 46′ W., 39° N.), in October, 1894. In walking from the railroad station to the forest plats, a distance of a mile, it was observed that the ground was cracked by the excessive drought, and it could scarcely have been harder; but in the cultivated soil of the nurseries and tree plats fresh soil was found a few inches below the surface.

The great lesson to be learned from these general observations is that deep plowing and frequent cultivation of the soil until it is shaded by the tree growth is one of the requisites for successful forest planting in these regions.

OBJECTS OF TREE PLANTING.

Without entering into a discussion of the causes of the failure which, in the majority of cases, has attended the efforts of tree planters in the States west of the Missouri River, it is intended to give practical suggestions on methods of planting and culture, with information regarding varieties of trees and the aftertreatment of cultivated woodlands.

The region under consideration is so vast in extent that it will be impossible, in a limited space, to give specific directions for planting or care under all the varying conditions of soil, altitude, moisture, wind, and the many minor items constituting what is known to the forester as locality.

Being intended primarily for farmers, the subject is treated from the standpoint of the agriculturist rather than that of the forester. The farmer, devoting comparatively small areas to the cultivation of trees, can regard the individual tree as his unit; the forester, having to do with thousands of acres, must look to the aggregate growth. Nevertheless, if the farmer would have timber from his grove that will best meet his varied needs, he must follow the same principles of selection, planting, and aftertreatment that govern the operations of the forester in his larger field.

In the Western States forest-tree planters have two special objects

in view—protection from winds and a supply of wood. Incidentally the plantations may be made to save much moisture to the tillable area of the farm; they also furnish a most important means of relieving the otherwise monotonous landscape, making the country more attractive. The great benefit derived from grove planting in the West, outweighing all other considerations, is protection from wind. Hence the groves should be so placed as to afford the most complete shelter to the farm buildings, feeding lots, garden, and orchard

A careful examination of a large portion of the region under discussion emphasizes a belief, founded on several years' experience in tree culture in South Dakota, that over the greater part of the vast area trees can be successfully grown without irrigation. The degree of success will be greatest on the eastern borders of the plains, and will decrease westward, following the general reduction in the moisture supply of soil and atmosphere. So, also, trees will be found to grow best on the lower lands near the streams, but as the country is settled and the land is cultivated the line of successful tree growth will ascend to the higher altitudes in every part of the plain region, and ultimately the entire area can be afforested.

AVAILABILITY OF SPECIES.

The work of tree planting on the plains heretofore has been largely tentative. In the beginning there was no experience that could be used as a basis in the West, because deductions from plantings made under other climatic conditions proved almost valueless. For the first time in the history of the world, a people attempted to transform, almost in a decade, a land that had long been considered an uninhabitable desert. The paramount condition that led to a choice of varieties of trees for planting was availability. There was no question on the part of the settler of the necessity for wind-breaks. The need was so urgent that he sought the quickest solution of it and took from the sparse woodlands of the nearest streams the species that seemed to grow most rapidly. Hence throughout the West the cottonwood is the most generally planted tree, and it has served a purpose which probably no other species could have so well filled. It has made a protecting wind-break around thousands of homesteads. Next to the cottonwood the willow, box elder, and maple have been most extensively planted, these being the most rapid growing, during youth, of the native species. Throughout the West, however, hundreds of farmers have secured seed of more valuable species and have attempted their cultivation, with varying degrees of success. Throughout the eastern parts of Kansas and Nebraska thrifty groves of black walnut and green ash can be found, and there are many plantings that contain a variety of hard woods, including, in addition to those already named, the black and honey locusts, elm, cherry, and catalpa.

To a much more limited extent pines and spruces have been planted, but a lack of knowledge regarding their needs has resulted at best in only a moderate degree of success.

In these pioneer plantings, as in the wild state, trees have grown best nearest the eastern border of the plains, the artificial groves decreasing in number and in size to the westward.

The species most easily secured, because native along streams in the plains, are cottonwood, box elder, green ash, silver and red maple, willow, and hackberry. Of these the cottonwood and willow may be regarded as the most available, because they grow readily from cuttings, as well as from seeds. The silver and red maples are both of common occurrence in Kansas, but northward the red maple becomes scarcer, and is not found in the Dakotas. The maples have a less general distribution, but they grow so readily and strongly from the seed that they have been largely planted. The ash and elm, being slower growers, have not commended themselves to Western planters as their merits deserve, but are now being more extensively planted.

In the eastern plain region, especially southward, several species of oak are native, the most useful being the bur or mossy cup (*Quercus macrocarpa*), also the black wild cherry, honey locust, sugar maple (rare), red elm, sycamore, walnut, several hickories, red cedar, basswood, and buckeye. It is thus seen that a goodly number of tree species are indigenous, and seeds of all of them can be obtained in greater or less quantity without much difficulty, the most widely distributed being those first named.

It may happen, however, through the instrumentality of the nurseryman and seedman, that species not native are more available than indigenous trees. The hardy catalpa is particularly available for the southeast plain region, because the seed is cheap and the tree can be grown with ease. For the same reasons the black locust is specially adapted to Kansas, southern Nebraska, and Colorado. Among conifers the Scotch and Austrian pines, red cedar, and white spruce are yearly becoming cheaper, and hence more available to the Western planter.

In addition to these larger trees, smaller woody growths, such as wild plum, choke cherry, and sand cherry, can be secured over the greater part of the West, and may fill an important purpose in the groves.

ADAPTABILITY OF SPECIES.

The adaptability of a species is its power to adjust itself to the conditions in which it is placed. A great many failures have been made in tree growing by mistaking availability for adaptability. It does not follow because the cottonwood is growing along the Arkansas, Republican. Platte, and Niobrara rivers all the way across the plains that it will succeed equally well on the intervening highlands. It

seems able to stand almost any degree of atmospheric dryness, provided it has a plentiful supply of moisture at the root. This might appear at first thought to be equally true of all arborescent species, but the fact that so few varieties of trees are found between the one hundredth and one hundred and fifth meridians indicates the contrary. The Arkansas is a broad river throughout the driest seasons, but in western Kansas and eastern Colorado almost the only species that grows on its banks is the cottonwood. This tree is much shorter lived on high land, especially where there is a stiff subsoil, and does not live as long when planted closely as when used for street planting—a single row with wide intervening spaces; even where it grows naturally, along rivers, it soon dies out.

The black walnut has been more extensively planted than any of the slow-growing trees, with the possible exception of green ash, and here again no attention has been paid to adaptability. The black walnut succeeds best in the deep, fresh soils of bottom and second-bench lands, and in such localities there are many successful young groves in Kansas and Nebraska; on the drier highlands, however, it is much slower in growth and often fails entirely.

The silver maple has been planted extensively throughout South Dakota, where it almost invariably kills back during its early years, resulting in a coppice form that makes an acceptable soil cover but a poor tree.

The box elder succeeds much better in the Dakotas than in Kansas, where it dies in high ground after a few years, and as a nurse tree is never as satisfactory as it is farther north. On the other hand, the Russian mulberry attains a good post size in the valley of the Arkansas—a thing incredible to those who have only seen the species as grown farther north, where it becomes a spreading shrub.

The hardy catalpa (*Catalpa speciosa*) is one of the most rapid-growing trees in the southeastern part of the plains, and thrives as far north as Omaha, Nebr., but it kills back in central Nebraska, even at the south line of the State, and will not grow at all in South Dakota. The black locust flourishes over a much greater western range, growing well under irrigation at Denver, Colo., and in the dry plains of western Kansas, but it is not successful north of the Nebraska sand hills.

It is seen from these examples that not only considerations of moisture but of temperature also must be regarded in determining the adaptability of a species to any locality.

Generally speaking, none of our trees succeed as well in the highlands of the West as in the valleys, and the reason is evident. Aside from the great difference in soil moisture, the lower lands have, as a rule, a much deeper surface soil, and the atmosphere of the valleys is measurably protected from wind action, so that the evaporation is relatively less—a point second only in importance to the moisture supply. While it is true that few, if any, species grow as rapidly on

the higher land, some are comparatively successful there. On deep soils the black wild cherry, catalpa, white elm, honey locust, black locust, hackberry, bur oak, box elder, bull pine, Scotch pine, Austrian pine, and red cedar do well in places where the temperature is suitable. Perhaps no tree in the above list is more widely adapted to varying conditions than the Scotch pine, which seems to be equally at home in the dry prairies of eastern Dakota and northern Nebraska (longitude 100° W.), the clay soils along the Missouri, the limy loams of the Kansas River bluffs, and the sandy loams of the Arkansas Valley.

OBJECTIONS TO PLANTING SINGLE SPECIES.

Pure planting is a term applied to plantations of a single species. In nature this condition is seldom found in the West, except along rivers where a grove of willows or cottonwoods has sprung up, or in the mountains where the pines or the spruces often form by themselves dense forests.

Pure planting is not to be recommended on the plains for several reasons. In the first place, the trees, being all of the same species, have the same form and rate of growth. If any accident or insect injure them on a considerable area, the soil is at once exposed, and a weed growth quickly takes possession of it.

In the second place, all the trees demand an equal amount of light, and this causes a crowding that will result in the premature death of many. If the kind selected be a sparsely shading sort, such as cottonwood and the locusts, a rank growth of weeds and prairie grasses will spring up and rob them of soil moisture, thus checking their growth.

The various uses of the farm demand a variety of timbers. A pure grove, even though successful, will not be as valuable to the farmer as a mixed grove.

RULES FOR MIXED PLANTINGS.

In planting timber trees, whether the area to be covered is 5 or 5,000 acres, certain principles should govern the work. It is desirable that the kinds selected be adapted to a variety of uses, that the plantation make a good wind-break, and that the trees be brought to maturity at the least possible cost to the planter.

Having determined what varieties are suitable to the locality, the mixing of two or more kinds depends (1) on their relative capacity for preserving or increasing favorable soil conditions, (2) on their relative dependence on light and shade for development, and (3) on their relative height growth.

Based on these principles, the following rules have been formulated:

(1) The dominant species, that is, the one occupying the most of the ground, must be one that improves the soil; in the West a shade-making kind.

(2) Shade-enduring (densely foliaged) trees may be mixed together when the slower growing can be protected from the overtopping of the more rapid growing, either by planting the slower growing first or in greater numbers or larger specimens, or by cutting back the quicker growing ones.

(3) Shade-enduring kinds may be mixed with light-needing kinds when the latter are either quicker growing, planted in advance of the former, or larger specimens.

(4) Thin-foliaged kinds should not be planted in mixtures by themselves except in very favorable locations, such as river bottoms, marshy soils, etc., where no exhaustion of soil humidity need be feared, or on very meager, dry soils, where nothing else will grow.

(5) The introduction of individual light-foliaged trees is preferable to placing them together in groups unless special soil conditions make the occupation by one suitable kind more desirable.[1]

There are difficulties in the application of these rules to Western planting that will at once suggest themselves. The first is that among the species available to the farmer very few are shade enduring, and a second is that as the trees grow older they change somewhat in reference to their shade endurance. The black wild cherry, for instance, endures much more shade during its youth than after it has attained its principal height growth. It has here been included among the shade-enduring kinds with this understanding. It should also be remembered that moist soils increase the shade endurance of all species, and vice versa.

RELATIVE SHADE ENDURANCE.

Considering first the species that are most available in the West, a series arranged with reference to shade endurance would read about as follows: (1) Box elder, Russian mulberry (red cedar, Douglas spruce, white spruce, Norway spruce); (2) black wild cherry; (3) hackberry; (4) silver maple; (5) bur oak; (6) green ash, catalpa (Scotch pine, bull pine); (7) black walnut; (8) honey locust; (9) black locust (larch), and (10) cottonwood.

The best shade-enduring variety probably is the sugar maple. In the Dakotas and northern Nebraska the box elder answers tolerably well during youth, and is unquestionably the most available species for this purpose. Farther south the Russian mulberry may be substituted.

The relative shade endurance of the conifers is indicated in parentheses in the above list, for the reason that the high prices charged for such trees have thus far prevented their extensive use in Western tree planting. For the same reason they have been given a much less important place in the planting schemes which follow than would otherwise have been warranted.

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[1] See annual report of Division of Forestry, 1886.

At least two-thirds of the plantation should be of dense-shading trees, among which the light-demanding species should be planted singly, so that each tree will be surrounded by shade-enduring kinds. To insure the greatest degree of success three-fourths or more of the grove should be shade-enduring kinds.

The special importance of completely shading the ground as soon as possible in Western tree culture is the necessity of preventing grass growth. The prairie grasses are exceptionally vigorous growers, and are all light-demanding species. Once established, it is difficult to eradicate them, and they seriously check the tree growth. Thousands of promising cottonwood groves have been ruined by permitting the grasses to get a foothold in the plantation. None of the light-foliaged trees make sufficient shade to prevent grass growth; so that the planter must either continue cultivation, which is too expensive a process, or use dense-shading trees for the major part of his grove. Indeed, the subject of light requirement is of the first importance in forest tree-culture anywhere. Heretofore it has received practically no attention in the West, and the above placing of species may have to be changed with more extended observation and experiment under Western conditions.

RATE OF DEVELOPMENT.

The varieties to be mixed should be chosen not only with reference to their light requirement, but also to the period of their development or rapidity of growth. To the Western planter shelter from winds is the most important object to be attained, and in order to accomplish this at the earliest possible time the majority of the trees should be quick growers. It seldom happens that rapid growers yield a timber valuable for economic uses, the catalpa and black locust being notable exceptions, and they can only be grown in a restricted territory. The cottonwood grows faster than any other Western species, but it is valueless for home use except as fuel, and it is of the poorest quality even for that purpose. The box elder and soft maple are but little better. These are trees of the earliest maturity, and the two last named are among the most available shading kinds. Cottonwood is almost useless in mixed planting. The plantation, then, should be made up largely of these quickly maturing species, even though they are of but slight economic value. Distributed singly among them should be trees of a slower rate of development, chosen also with a view to their light requirement. If one-half or two-thirds of the plantation be of box elder, for instance, at least half of the remaining trees should be of a shade-enduring kind, that will continue to keep down weed growth by keeping the soil shaded after the box elders are thinned out. The remainder of the species may be of high economic value and slower maturity, such as bur oak, black walnut, and ash, or they may be rapid growers which demand a great deal of light, such as black locust and catalpa, or they may be pines, or all these may be introduced, but

under all circumstances their light requirements should be kept in mind, and they should be so distributed as to afford to each the best opportunity for development.

It will be seen from what has been said that the rapid-growing species, like box elder, Russian mulberry (in the more southern regions only), and silver maple, while affording protection from winds almost as soon as cottonwood, are serving as nurse trees to the more slowly maturing kinds which grow among them, compelling them to reach up for light, and thus forcing them to grow tall and straight and to store the most of their wood in the shaft and form the least possible number of branches during their youth. In this way the value of the more permanent trees is greatly increased, for the trunks at maturity are long, straight, and free from knots, thus making the best possible lumber.

According to their rate of development, our more available species for Western planting may be arranged as follows, the most rapid growing being named first: Cottonwood, box elder, silver maple, black locust, catalpa, European larch, honey locust, white elm, hackberry, Scotch pine or bull pine, black wild cherry, black walnut, white spruce or Douglas spruce, red cedar, green ash, bur oak.

CLOSE PLANTING.

One of the principal causes of failure in Western tree planting has been wide spacing. It is not uncommon to see trees set in rows 12 and even 16 feet apart, 1 to 2 feet apart in the rows. This wide spacing of rows requires long-continued cultivation, otherwise the trees are soon given over to the grasses, which rob them of soil moisture and effectively check their development. Or, what is even worse, the forest trees are set as in an orchard, 9 or 12 feet apart both ways. This planting permits a great development of lateral branches, resulting in very short trunks, which, as the trees grow older, form bad forks near the ground. This plan also demands long-continued cultivation in order to keep out weeds and grasses.

Aside from the more complete protection afforded, close planting is the most economical method of cultivation in the West. It is true that if trees are purchased, the first cost of material is greater, as also the cost of planting, but these items are more than balanced by the saving in cultivation and the assurance of success.

The Western planter is measurably restricted by the number of species of trees that will succeed in his locality; but while the climate limits the number of species that he can grow, there is yet a wider range of choice than has thus far been exercised. As already indicated, the major part of a Western plantation should be of a dense-foliaged, quick-growing species; and in the choice of this variety the planter is limited to one or two kinds. For the remaining trees of his plantation, however, there is quite a wide range of choice, and the

plantation should be sufficiently varied in its forms to meet all possible needs. With careful management, a plat of 20 acres of forest trees, well selected and properly grown, can be depended upon to supply the ordinary Western farm with the greater part of the timber needed upon it, though it could not be expected to supply fuel. If the farmer desires to grow post timber, black locust is one of the best trees he can plant; but this tree does not succeed north of Nebraska. It is a light-demanding species, and is subject to borers, and hence should be distributed singly among shade-making kinds. If wood for machine repairs is wanted, green ash is best adapted to the purpose. It can be raised throughout the West, but is also a light-demanding species and must be grown among shade-making kinds. These illustrations will show the importance of including in all plantations a number of species of timber trees having varied characteristics.

ILLUSTRATIVE TREE MIXTURES.

The best distance at which to plant is 3 by 3 feet, and next to this is 4 by 4 feet, the latter spacing being the widest that should be used on the plains.

At 3 by 3 feet, 4,840 trees will be required for an acre; at 3½ by 3½ feet, 3,781, and at 4 by 4 feet, 2,722. In the southern part of the plain region, Russian mulberry, catalpa, black wild cherry, black locust, green ash, bur oak, white elm, black walnut, and Scotch pine could be used in mixture according to the following diagram:

M	A	M	L	M	A	M	L	M	A	M	L
C	M	C	BC	C	M	C	BC	C	M	C	BC
M	L	M	O	M	L	M	P	M	L	M	O
C	BC	C	M	C	BC	C	M	C	BC	C	M
M	E	M	L	M	E	M	L	M	E	M	L
C	M	C	BC	C	M	C	BC	C	M	C	BC
M	L	M	W	M	L	M	P	M	L	M	W
C	BC	C	M	C	BC	C	M	C	BC	C	M
M	A	M	L	M	A	M	L	M	A	M	L
C	M	C	BC	C	M	C	BC	C	M	C	BC

M, Russian mulberry; C, Hardy catalpa; A, Green ash; E, White elm; L, Black locust; O, Bur oak; W, Black walnut; P, Scotch pine; BC, Black wild cherry.

The number of trees of each species required for an acre would be as follows:

Mulberry	1,815
Catalpa	1,210
Black wild cherry	605
Black locust	605
Green ash	151
White elm	152
Bur oak	75
Black walnut	75
Scotch pine	152
Total	4,840

An inspection of the above diagram will show that the mulberry, catalpa, and black wild cherry, shade-enduring trees, constitute three-fourths of the planting, leaving the remaining fourth to light-demanding species; black locust, a rapid-growing tree and one of our very best post timbers, makes up one-half of the light-demanding species; green ash, white elm, and Scotch pine (for which ash could be substituted) each constitute one-fourth of the remainder, while bur oak and black walnut, at intervals of 12 by 24 feet, fill the remaining places. The mixture has been arranged with reference to the light requirement of the trees. Catalpa and mulberry alternate with each other in the rows, so that at the thinning time, if it is desirable to remove either, the other will protect the soil. The catalpa pushes late in spring and its leaves drop with the first frost, so that alone it is not a good nurse tree; but mixed with mulberry, which has an earlier and more persistent foliage, the defect is measurably overcome. The catalpa, grown close, will make poles in five to ten years, so that if at the first thinning this variety is removed it will give an abundance of room for the other trees—admitting light not only to its own rows, but to the more permanent trees adjoining it—and will yield a good return in sticks large enough for pole fencing, stakes, or stove wood.

When the catalpa is removed, the black wild cherry and mulberry will soon close the breaks made in the leaf canopy, and thus weed growth will be prevented. At the next thinning, in from fifteen to twenty years, the mulberry will be large enough to make from two to four posts per tree, or, if deemed more desirable, a part of the black locusts will be found large enough for use. By this time the cherries should average 30 to 35 feet in height, and it may be necessary to aid the oaks, either by removing the adjacent mulberries and cherries, or by cutting their lateral branches. All the trees will have been forced to grow tall and straight.

For the more northern part of the plains the number of species would have to be reduced or substitutions made, as experiments seem to indicate that the shade-enduring species are box elder and black wild cherry, and the light-demanding forms that have proved successful are white elm, green ash, bur oak, cottonwood, Scotch pine, and Austrian pine. Red cedar and the spruces are shade enduring, and the bull pine (*Pinus ponderosa*) of the Black Hills will doubtless be a useful addition to this list.

The white spruce or Douglas spruce could be substituted for catalpa, box elder for mulberry, and white elm for locust, increasing the number of green ash to 302 in place of the white elm indicated in the mixture; or, if only broad-leafed trees are to be used, the following mixture could be made:

B	B	B	B	B	B	B	B	B	B
B	A	B	C	B	E	B	C	B	L
B	B	B	B	B	B	B	B	B	B
B	C	B	L	B	C	B	A	B	C
B	B	B	B	B	B	B	B	B	B
B	A	B	C	B	E	B	C	B	O
B	B	B	B	B	B	B	B	B	B
B	C	B	L	B	C	B	A	B	C
B	B	B	B	B	B	B	B	B	B

B, Box elder; A, Green ash; C, Black wild cherry; E, White elm; O, Bur oak; L, Yellow birch.

On the basis of this diagram it would require per acre, planted 3 by 3 feet, the following number of trees of each species:

Box elder	3,630	White elm	201
Black wild cherry	607	Yellow birch	151
Green ash	201	Bur oak	50

In this mixture, box elder is used as the early maturing, dense-foliaged form, and constitutes three-fourths of the trees. They are so placed that the alternate trees in the solid box-elder rows may be removed, and the more permanent trees will still be surrounded by good shade-making kinds. Should all the nurse trees be removed, the black wild cherry, constituting one-half of the remainder of the plat, would become the dominant tree, and, being a shade-enduring kind, would act relatively the same as box elder. The cherries are so placed that if all the box elders were cut out, the lighter-foliaged forms would each be surrounded by cherries. The box elder will not make as useful a timber for any purpose as catalpa, but the latter species is not hardy north of central Nebraska, and grows poorly west of the ninety-ninth meridian in Kansas, so that it is only available in a comparatively small part of the West. The cottonwood is not recommended, as other and better trees can be grown in its place. The box elder grows rapidly only during its youth, and within ten or fifteen years the remaining trees may be expected to overtop it; but where fuel is as scarce as on the plains, even the first box-elder thinnings, at seven to ten years from planting, will be found very useful for firewood.

The black locust can be grown throughout Nebraska south of the sand hills, but it does not succeed in the northern part of the plain region, nor does the honey locust, though this will stand in the southern counties of South Dakota. The mixtures here suggested are given not as ideal ones, but to illustrate the practice. The important point to be observed is the necessity of having a good shade maker as the dominant tree in the beginning, and providing for a suitable distribution of the light-demanding species among the permanent shade-enduring kinds.

CONIFERS FOR WESTERN PLANTING.

The climatic conditions throughout the States between the Mississippi River and the Rocky Mountains seem to indicate that the cone-bearing trees are better adapted to the plains than are the broad-leafed species. The excessive evaporation of the plains, due in a great measure to the constant winds, is much more trying to deciduous trees than to evergreens, the foliage of which is especially designed to withstand it.

Experiments have been conducted in the cultivation of conifers in the West, but they have been almost invariably attended with only a small measure of success, or have failed entirely. The few exceptions, however, prove that it is possible to make certain of the conifers live, and that, once established, they thrive where broad-leafed trees fail (as in the sand hills).

It should be stated that as a people we are unfamiliar with the handling of young cone-bearing trees, but having had large experience, one way and another, with deciduous forms, we have a much better understanding of the requirements of the latter. Undoubtedly most of the failures with conifers in the West have resulted from ignorance on the part of the shipper, the buyer, and the planter. In digging deciduous trees but little care is necessary to protect the roots. Indeed, the writer has received a lot of oak trees the roots of which looked so dry that they were planted without any expectation of their growing, but only a small per cent of them failed; and others, notably the green ash and catalpa, will stand a great deal of abuse of this sort. The conifers, however, have a very different root system, and require different handling. Take almost all of the broad-leafed trees that thrive in the West, and in their seedling stage they have either a heavy taproot, like the catalpa, walnut, and ash, or several equally strong main roots springing from near the collar, which have but few rootlets. The conifers, on the other hand, have a mass of fine rootlets by the time they have attained a size for transplanting, and even were other things equal, these very fine roots would dry out much quicker than the larger roots of the broad-leafed trees.

The fact that the roots of young cone-bearing trees dry out quicker, with greater resulting injury, than those of other tree forms can easily be established by exposing elm or cherry and larch seedlings for a few hours and then planting them. The former will be none the worse for its sun bath, but the latter will fail to grow. The roots of cone-bearing plants should not be exposed to the drying action of the air from the time they are taken up until they are transplanted. As the young conifers are dug their roots should be plunged in water or puddled in mud. In the storehouse, during the interval of packing, they should be protected by damp moss. In transit they should be so packed as to avoid heating on the one hand, and drying out on the other. When received by the planter, they should at once be separated, puddled, or dipped in water, and carefully "heeled in"

(covered temporarily with moist earth) in a shaded location until they can be set. When the planting season arrives, a moist, cloudy day should, if possible, be chosen for the work, and the young trees should be taken from their temporary resting place and carried in vessels of water to the field.

In planting, none but fine moist soil should come in contact with their roots, and this should be tramped very firm, so that the fine soil will be brought into close contact with the rootlets. Then if an inch of loose soil be spread over the top, making the surface level and preventing drying out, the tree will have been well planted. The cone-bearing trees, as a rule, do not start so readily as the broad-leafed species. They have as great, if not a greater, supply of stored food, and push their buds vigorously, but the roots do not take hold of the soil so readily, new roots are not formed, and as a result the trees frequently perish after a seemingly excellent start has been made.

The conifers are of very great utility in Western planting. Being evergreen, they make far better wind-breaks than do the deciduous trees, and herein is their peculiar value. Tree planting on the plains, at least under existing conditions, can hardly be expected to assume the proportions of forest planting, and hence the economic value of the wood of pines and spruces is of minor importance. They do not furnish as strong lumber as do the ash and oak, and are not so durable in contact with the soil as black locust and catalpa; hence for the ordinary farm uses the timber of the conifers is not especially desirable.

FOREST PLANTING IN THE SAND HILLS.

An experiment in the planting of forest trees in the sand hills of Nebraska has been described in the annual reports of the Division of Forestry, and the results thus far attained seem to indicate that the first step in this direction will be the growth of Banksian pine on the sand ridges. These sand hills occupy approximately an area 250 miles long (east and west), and from 50 to 70 miles across. The country is traversed in all directions by high hills composed of almost pure sand, interspersed with grassy valleys which are good grazing and hay lands. The hills are covered with a sparse growth of grasses and weeds, scarcely enough to bind the sands, which are frequently blown out in large areas, often making great holes a hundred yards in diameter in the sides of the hills. The wind and blowing sand make the valleys almost uninhabitable, and even were these difficulties removed the soil of the valleys is very shallow, and will not long bear cultivation. The experiment undertaken by the division had for its object the determination of what species would grow on these sand hills.

Without going into details, which have been already reported, it may be said that of a number of species of deciduous and coniferous trees planted only one shows decided adaptability to this unfavorable

locality. The Banksian pine, planted on the highest ridges in the heart of the sand hills four years ago, seems thus far well suited with its surroundings; all the deciduous trees are dead, and only a few ponderosa, Scotch, Austrian, and red pines remain. The land was not plowed, as such a procedure would have caused it all to blow away. Furrows 2 feet apart were turned, and the little trees, 6 to 10 inches high, were planted in these furrows so as to be slightly shaded by the ridges formed in making them. The Banksian pines are now from 18 inches to 4 feet high, and are each year growing more than the last. The sand of which the hills is composed is fine, like clean river sand, and during the driest seasons moisture can be found only a few inches below the surface. If this great area, lying almost midway between Texas and the British Possessions, could be covered with forest trees, a noticeable improvement in the climate of the plains would result.

From the action of the other species of pine noted it is safe to infer that after the Banksian pines are a few feet high, and able to afford slight protection, other and more valuable species can be grown in their shade. The Douglas spruce (*Pseudotsuga douglasii*) has not stood as well as the pines in this experiment, nor is this surprising when the greater shade endurance of this species is recalled. It is reasonable to hope, however, that this valuable species can be established in the shade of the Banksians, and that once established it will serve as an excellent nurse for the more rapid-growing pines. After these have been cut off the spruce will be left as the dominant trees.

Every forest experiment in the sand hills should have as its ultimate aim an extent great enough to warrant systematic management, conducted on the general principles laid down in the annual report of the Division of Forestry for 1891. Judging by the action of the trees in the Nebraska sand hills experiments thus far, the following diagram illustrates what might be a safe planting scheme:

B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P

Distance between trees, 2 feet each way. Number of trees to the acre, 10,840, of which 6,775 are Banksian pine, 2,710 Douglas spruce, and 1,355 pines of one or more of the following species: *Pinus ponderosa*, *P. sylvestris*, and *P. resinosa*.

The Banksian pines would only be expected to stand until the others were established, and could be given the start by two or three years.

From the action of the trees in the Nebraska experiment, it would seem that the Douglas spruce, if used at all, should not be set until at least three years after the Banksians. In case the spruce is omitted entirely, the Banksian should be set in its place.

GENERAL CULTURAL NOTES.

With the exception of the sand hills, general suggestions may be made which will be applicable to the cultivation of forest trees throughout the plains.

Preparation of the soil.—In the preparation of the soil too much importance can not be attached to depth of plowing. The Western prairies, through long exposure to the action of the elements and to the tramping of the countless herds of buffaloes, which for centuries found in them a favorite pasture ground, have become far more compact than the forest-protected soils of the East. After a prolonged drought, such as frequently occurs, the autumn rains are not readily absorbed by the hard soil, and much moisture that might be saved to crops runs off and is lost to the fields. This is particularly true of the western parts of Nebraska and Kansas, and eastern Colorado. The same lands under deep tillage act very differently. Not only is the absorbing power of the soil increased by deep plowing, but the ability of such soil to retain moisture, under proper culture, is marked.

Land should be gradually prepared for tree planting by increasing the depth of plowing during three successive years, if so much time can be given to the work. The usual practice in the West is to break the land in June or July, turning as thin a sod as possible, and laying it flat, for which purpose the breaking plows are well adapted. Sometimes, on early breaking, a crop of sod corn or flax is grown the same year. After one crop is removed, the land is backset, when an inch additional is turned. For tree planting the depth should be increased from 2 to 3 inches at a time, until at the end of the third year the land may be plowed 10 to 12 inches deep. The advantage of this gradual preparation is in the complete subjection of the native growth of grasses and other herbaceous plants. This is a most important point in the economic growing of trees on the plains. If the native growth is entirely subdued, so that no live grass roots are present in the soil when the trees are planted, a great deal of after-labor is obviated.

One of the most obvious difficulties in the way of successfully meeting the requirements of the timber-claim law, which resulted, in spite of its defects, in so much good to the Western States, was the short time allowed between breaking the prairie sod and planting the trees. It was almost impossible under the methods of farming in vogue in the West to kill out the native vegetation in two seasons, but by gradually increasing the depth of plowing and by planting hoed crops the season preceding the setting of trees, the land can be completely

subdued. Deep-plowed land will absorb much more of the melting snows and the spring rains than shallow-plowed land with the compact underclay within a few inches of the surface. By the time the planting season opens, in a year of ordinary rainfall, a deep-plowed field will be in excellent condition to receive the trees so far as moisture is concerned.

Thorough pulverizing of the soil is but little less essential, as a preparation for trees, than deep plowing. The particles of the soil should be fine in order that they may be brought in close contact with the roots of the trees, and thus supply them with moisture. If the field is rough and full of clods, the land will dry out rapidly. The thorough use of the disk harrow, clod crusher, pulverizer, and smoothing harrow is quite as important in preparing land for trees as in the preparation of a field for a crop of wheat. Not only will trees start more quickly when set in well-prepared soil, but the growth will be more uniform and strong.

As in all other hoed or cultivated crops, it is important to keep the surface of the soil in fine tilth until the trees have grown sufficiently to shade the ground. Deep plowing and shallow cultivation should be the rule in all kinds of Western farming. The deep plowing gives a large absorptive area, and shallow cultivation places over the moist soil a dust blanket that acts as a most effective mulch, checking evaporation and thus retaining the soil-moisture for the use of the trees. The Western planter must keep constantly in mind the necessity of saving, by every possible means, the moisture of the soil. In the Eastern States, which have a well-distributed rainfall of from 30 to 50 inches, this is a point of comparatively little consequence; but beyond the Mississippi its importance increases as one goes westward.

Planting trees.—In planting trees careful alignment will save much labor in cultivation. It will pay to mark the land as carefully as for corn where groves of 10 acres or less are to be set, and to begin planting all the rows from the same side of the field, as the slight deviation resulting from pressing the spade forward in planting will thus bring all the trees in even crossrows. Almost all seedling forest trees can be set with a broad dibble or spade, which is sunk blade deep at the cross mark, the soil pressed forward, the roots so inserted as to avoid turning the tip upward, and the soil pressed firmly about the collar with the feet, brushing a little loose dirt over the pressed places to prevent baking. When planting in this way, the seedlings can be carried in a pail with a little water or moist earth. In mixed planting it will be found most convenient to set all the trees of the prevailing species first, leaving the places for the kinds that are to be used in smaller quantity to be planted afterwards. Where two or three shade makers are used the same method can be followed, or each kind may be handled by a different planter, all working together.

It is also desirable to take all the trees to the plat to be planted

and heel them in where they can be easily reached. Special care should be taken to prevent the drying of the roots of conifers. Where the roots are large and fibrous, it will be found best to dig a hole for the trees, setting them in the same manner that orchard trees are planted. Care should be taken to secure perfect alignment in this method, as when the rows are irregular it is impossible to bring the cultivator close to the trees.

Exposure of roots.—It occasionally happens in the West that during the early summer, or after the leaves have dropped in the fall, the surface soil will be blown away by the hard winds, exposing the roots to the drying atmosphere. To prevent this, the trees should be set an inch deeper than they grew in the nursery, and in autumn, after the leaves have fallen, a shallow furrow should be turned to the trees, so as to throw the dirt against the trunk. This can be done with the shovel attachments of the ordinary wheel hoe, which is one of the most useful implements that can be used in the young tree plantation.

Cultivation.—The amount of cultivation beneficial to young trees can not be determined by freedom from weeds, nor by the number of times the operation is performed. In seasons of prolonged drought frequent stirring of the surface soil will be found of great benefit, as it will keep over the surface a layer of loose, fine earth, which will quite effectively check evaporation from the moist soil below. After rains the stirring of the surface soil will prevent the formation of a crust, which indicates the too rapid loss of water from the soil. Weeds and grass should be kept out of the trees, because they use the moisture that will be needed for tree growth. Ordinary shallow cultivation will be found sufficient for annual weeds—including the Russian thistle, sunflower, and mustard—if begun early and continued regularly, but the only way to get rid of the couch grass (*Agropyrum repens*) is to carefully dig out its underground stems and remove them. It is well to be on the watch for this pest, for when once established among trees it is almost impossible to eradicate it.

Cultivation should cease at midsummer, in order not to encourage too late growth and consequent danger of winterkilling. Thereafter large weeds can be cut out with a hoe, or a thin crop of oats or buckwheat can be sown among the trees to hold the soil during the drying winds of late summer and early autumn. After the leaves fall, a shallow furrow turned against the trees will prevent exposure of the roots by the late fall and early spring winds.

The best implement for cultivating young trees is a harrow-tooth culivator. The horse hoe, with its varied attachments, is useful in the tree plantation, as well as in the fruit and vegetable garden. During the first year a two-horse cultivator can be used, but it should always work shallow; the result, however, is not so satisfactory as with the finer-toothed machine.

Two or three years, depending on distance and upon the season, should be sufficient for the cultivation of any carefully designed mixture of forest trees. At the beginning of the second season all blanks should be reset, and again the third spring. This should insure a full stand of trees. Thereafter the knife and pruning shears must take the place of the cultivator.

Pruning a young plantation.—In a properly designed plantation of forest trees very little pruning is necessary, though the temptation to use the knife is often great. If in passing through the plat a tree of upright habit is found to be forked near the ground, or to be forming two leaders, one of the branches should be cut away.

If the shade-enduring trees are found to be overtopping the light-demanding kinds, the former must be headed in. This rule, however, must be used with judgment. It will often happen, as with the oaks, that the more valuable species is seemingly harmed by its neighbors, when in reality it is making strong root growth, and is none the worse for the temporary overtopping.

Many trees, like the black wild cherry, form a mass of fine branches while young and look as though they would never make a leader and grow to a single trunk. These should be permitted to grow without pruning in thick-set plantations. As soon as their neighbors begin to crowd them one of the many branches will take the lead, and the plant will assume tree form, the many lateral branches dying off as the stem grows upward.

It is no advantage to "trim up" young trees by the removal of their lower branches when they reach a height of from 12 to 20 feet, especially in mixed plantations and on the prairies. The very purpose of close mixed planting is to force the trees to prune themselves, and they can be depended upon to do this as it becomes necessary. The lower branches aid very much in making the plantation effective as a wind-break. While small and weak, in the aggregate they make a strong barrier to the wind, and should be left for this purpose, if for no other. A possible exception may be named in the catalpa; but even in this tree the lateral branches should only be removed as they show signs of dying, and then only because, being persistent and not shed after a year or so, as with most deciduous trees, they make defects in the timber of the trunk.

Thinning.—Thinning trees planted 3 by 3 feet is seldom if ever necessary until from five to seven years after planting; and at the first thinning the removal of comparatively few trees will be advisable. It may be best to head in some of these trees by clipping their lateral branches in the intervals between thinning, but our strong Western soils should be able to carry the full stand until from five to ten years old, and the subsequent thinnings should be at intervals of from seven to ten years.